

between two differential operational amplifiers Amp1 and Amp2. For the sake of simplification, one can draw a horizontal line through the ground wire and ignore the lower half of the schematic for the basic analysis. That is, the circuit operation may be described with reference to a single-ended embodiment.

(6) Note the "dB" values listed above the nodes of the upper half of the R-2R ladder. As discussed above, the R-2R topology inherently produces accurate -6 dB (50% attenuation) steps starting from the 0 dB node and extending to the end of the ladder, in this case to -114 dB (20 steps). It is important to note that since the Amp2 operational amplifier inputs form virtual ground nodes, each 2R resistor terminates into a zero-impedance node regardless of the position of its associated switch (SnA or SnB). According to a specific embodiment, the circuit ground of FIG. 2 may be eliminated by using the virtual ground effect of a differential signal, i.e., the ground nodes of each switch pair SnA and SnB may be tied together.

(7) According to a specific embodiment, the switch operation scheme is as follows: only one vertical pair of switches (e.g., S1A and S1B) is switched to the Amp2 inputs at any given time; all other switches are switched to ground. When the S1A/B pair are in the Amp2 position and all other switches are in the grounded position, the 2R resistors at S1A/B act as input resistors (Rin) for Amp2. The Amp2 feedback resistors (Rf) are also 2R, so the gain from the output of Amp1 to the output of Amp2 is unity. When S2A/B are in the Amp1 input position and all others are in the grounded position, the Amp1 to Amp2 throughput gain is -6 dB. This same sequence of switch control applies through the length of the ladder for all 20 possible gain selections. While Amp2 is configured for unity gain in this example, it will be

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54] METHOD AND APPARATUS FOR CONTROLLING AN AUDIO SIGNAL LEVEL

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ABSTRACT

A control circuit for controlling a level of an audio signal and transmitting the signal to an amplifier is described. The control circuit is based on an R-2R ladder network having a plurality of switch nodes. A plurality of switches alternately connects each of the plurality of nodes to one of a plurality of low impedance nodes and a low impedance input node associated with the amplifier. Switches cannot directly selectively connect the plurality of nodes to transmit the audio signal to the low impedance input node.

17 Claims, 5 Drawing Sheets

